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KLARQUIST SPARKMAN, LLP
121 SW SALMON STREET
SUITE 1600
PORTLAND, OR 97204

EXAMINER

DOUGHERTY, THOMAS M

ART UNIT

PAPER NUMBER

2834

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Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary

Application No.

10/033,353

Applicant(s)

RICHARDS ET AL.

Examiner

Thomas M. Dougherty

Art Unit

2834

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --
Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM
THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

- 1) ☒ Responsive to communication(s) filed on 02 June 2003.
- 2a) ☐ This action is **FINAL**. 2b) ☒ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

- 4) ☒ Claim(s) 1-107 is/are pending in the application.
- 4a) Of the above claim(s) _____ is/are withdrawn from consideration.
- 5) ☐ Claim(s) 95-103 is/are allowed.
- 6) ☒ Claim(s) 1-17, 19-94 and 104-107 is/are rejected.
- 7) ☒ Claim(s) 18 is/are objected to.
- 8) ☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☒ The drawing(s) filed on 25 October 2001 is/are: a) ☒ accepted or b) ☐ objected to by the Examiner.
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
- 11) ☐ The proposed drawing correction filed on _____ is: a) ☐ approved b) ☐ disapproved by the Examiner.
If approved, corrected drawings are required in reply to this Office action.
- 12) ☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. §§ 119 and 120

- 13) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
a) ☐ All b) ☐ Some * c) ☐ None of:
1. ☐ Certified copies of the priority documents have been received.
2. ☐ Certified copies of the priority documents have been received in Application No. _____.
3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).
* See the attached detailed Office action for a list of the certified copies not received.
- 14) ☒ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).
a) ☐ The translation of the foreign language provisional application has been received.
- 15) ☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

Attachment(s)

- 1) ☐ Notice of References Cited (PTO-892)
- 2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
- 3) ☒ Information Disclosure Statement(s) (PTO-1449) Paper No(s) 603.
- 4) ☒ Interview Summary (PTO-413) Paper No(s). 903.
- 5) ☐ Notice of Informal Patent Application (PTO-152)
- 6) ☐ Other: _____

The indicated allowability of the claims is withdrawn in view of the reconsideration of reference(s) to Ohio University, Bullock and Xu et al. actions based on International Search Report associated with the PCT application for this case. The office regrets the inconvenience.

Claim Rejections - 35 USC § 102

The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

A person shall be entitled to a patent unless –

(b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

Claims 1, 2, 4, 7 and 16 are rejected under 35 U.S.C. 102(b) as being anticipated by Ohio University (WO 94 18433 A). Ohio University shows (figs. 1, 2, 5a, 5b) a micro-transducer (see title) comprising: a first membrane (34); a second membrane (44) comprising a first electrode (512), a second electrode (518), and a piezoelectric member (522) disposed therebetween; a fluid-tight cavity (30, 40) cooperatively formed between the first (34) and second (44) membranes; and a working fluid (p. 4, l. 31) disposed in the cavity (30, 40).

Further comprising a low-temperature heat sink (22) disposed adjacent the first membrane (44) and a high-temperature heat source (14) disposed adjacent the second membrane (34) such that the transducer (35) is operative as a heat engine having a thermodynamic cycle (see Abstract), wherein thermal energy, flowing from the high-

temperature heat source (14) to the low-temperature heat sink (22) through the heat engine during the thermodynamic cycle, is converted into electrical energy (p. 7, ll. 3, 4).

Further comprising a low-temperature heat source (22) disposed adjacent the second membrane (34) and a high-temperature heat sink (14) disposed adjacent the first membrane (34) such that the transducer is operative (during compression) as a heat pump having a thermodynamic cycle, wherein electrical energy is consumed to transfer heat from the low-temperature heat source to the high temperature heat sink.

Wherein the first membrane (34) comprises a layer of silicon, and the second membrane (44) comprises a layer of silicon for supporting the first and second electrodes and the piezoelectric member. See p. 20, ll. 5-14.

Ohio University shows (figs. 1, 2, 5a, 5b) a structure having a plurality of micro-transducers (35), the structure comprising: a first major layer (14); a second major layer (22) juxtaposed to the first layer; a plurality of fluid-tight cavities (plurality is shown in fig. 1) cooperatively formed between the first (14) and second (22) major layers; a working fluid contained in the cavities (as noted above); a plurality of first electrodes (as noted in fig. 5b) carried by the first major layer (14) at each of said cavities; a plurality of piezoelectric members (522) carried by the first electrodes at each of said cavities (30, 40); and a plurality of second electrodes (as noted in fig. 5b) carried by the piezoelectric members (522) at each of said cavities (30, 40).

Ohio University shows a (figs. 1, 5) micro-transducer, comprising: a first membrane (44); a second membrane (34) comprising a first electrode (518), a second electrode (512), and a piezoelectric member (522) disposed therebetween; a fluid-tight cavity (30,

40) cooperatively formed between the first and second membranes; a working fluid disposed in the cavity; and a low-temperature heat sink (22) disposed adjacent the first membrane (44) and a high-temperature heat source (14) disposed adjacent the second membrane (34) such that the transducer is operative as a micro-heat engine having a thermodynamic cycle, wherein thermal energy, flowing from the high-temperature heat source (14) to the low-temperature heat sink (22) through the micro-heat engine during the thermodynamic cycle, is converted into electrical energy.

The first membrane comprises a layer of silicon; and the second membrane comprises a layer of silicon for supporting the first and second electrodes and the piezoelectric member. See p. 20, ll. 5-14.

The working fluid occupies the cavity.

Ohio University shows (figs. 1, 5b) a micro-transducer, as noted above, comprising: a first membrane; a second membrane comprising a first electrode, a second electrode, and a piezoelectric member disposed therebetween; a fluid-tight cavity cooperatively formed between the first and second membranes; a working fluid occupying substantially the entire cavity; and a low-temperature heat source disposed adjacent the second membrane and a high-temperature heat sink disposed adjacent the first membrane such that the transducer is operative as a micro-heat pump having a thermodynamic cycle (see Abstract), wherein electrical energy is consumed to transfer heat from the low-temperature heat source to the high-temperature heat sink (p. 7, ll. 3, 4).

The first membrane comprises a layer of silicon, and the second membrane comprises a layer of silicon for supporting the first and second electrodes and the piezoelectric member. See above

Ohio University shows, as noted above, a micro-transducer, comprising: a body defining a fluid-tight cavity, a compressible and expansible working fluid contained within and occupying the cavity (see the Abstract), the body having a piezoelectric unit situated adjacent the cavity, and the piezoelectric unit being operable as an actuator to compress the working fluid whenever an electric field is applied to the piezoelectric unit and operable as a generator to generate an electric charge whenever the working fluid expands; a heat source; and a heat sink, the heat source and heat sink being positioned relative to the body such that thermal energy flowing from the heat source to the heat sink flows through the working fluid.

As noted above, the heat source is a high-temperature heat source; the heat sink is a low-temperature heat sink; and the transducer is operable as a micro-heat engine according to a thermodynamic cycle in which thermal energy, flowing from the heat source to the heat sink through the working fluid, is converted into electrical energy.

As noted above, the heat source is a low-temperature heat source; the heat sink is a high-temperature heat sink; and the micro-transducer is operative as a micro-heat pump that consumes electrical energy while transferring heat from the low-temperature heat source to the high-temperature heat sink.

Ohio University shows (figs. 1, 5b) an apparatus for converting energy in one form to energy in another form, as noted above, the apparatus comprising: a first major layer;

and a second major layer juxtaposed to the first major layer, the first and second major layers forming a plurality of micro-transducers, each micro-transducer comprising a respective fluid-tight cavity formed between the first and second major layers, a compressible working fluid disposed in the cavity, and a respective piezoelectric unit formed on one of the first and second major layers.

Ohio University shows, as noted above, a micro-transducer, comprising: a body defining a fluid-tight cavity; and a compressible and expansible working fluid contained within the cavity, the body having a piezoelectric unit situated adjacent the cavity, and the piezoelectric unit being operable as an actuator to compress the working fluid whenever an electric field is applied to the piezoelectric unit and operable as a generator to generate an electric charge whenever the working fluid expands.

As noted above, the working fluid occupies the cavity.

As noted above, the body comprises a first membrane and a second membrane; the cavity is formed between the first and second membranes; and the piezoelectric unit is disposed on the first membrane.

Claims 1 and 16 are rejected under 35 U.S.C. 102(b) as being anticipated by Bullock (US 4,140,936). Bullock shows (figs. 6, 8) a transducer (1) comprising: a first membrane (21); a second membrane (3) comprising a first electrode (not shown), a second electrode (not shown), and a piezoelectric member (2) disposed therebetween; a fluid-tight cavity (16, 19) cooperatively formed between the first (21) and second membranes (3); and a working fluid (as shown) disposed in the cavity (16, 19).

Bullock shows (figs. 6, 8) a structure having a plurality (fig. 8) of transducers (1), the structure comprising: a first major layer (not numbered); a second major layer (not numbered) juxtaposed to the first layer; a plurality of fluid-tight cavities (16, 19) cooperatively formed between the first and second major layers; a working fluid contained in the cavities; a plurality of first electrodes(not numbered) carried by the first major layer at each of said cavities; a plurality of piezoelectric members (not numbered) carried by the first electrodes at each of said cavities; and a plurality of second electrodes (likewise not numbered) carried by the piezoelectric members at each of said cavities.

Claims 1-17 and 19-21 are rejected under 35 U.S.C. 102(b) as being anticipated by Xu et al. in the article "Design of a Micro Heat Engine". Xu et al. show in figs. 1-3, note however that the components are not numbered, a micro-transducer comprising: a first membrane; a second membrane comprising a first electrode, a second electrode, and a piezoelectric member disposed therebetween; a fluid-tight cavity cooperatively formed between the first and second membranes; and a working fluid disposed in the cavity.

Further comprising a low-temperature heat sink (fig. 1 at bottom) disposed adjacent the first membrane and a high-temperature heat source (fig. 1 at top) disposed adjacent the second membrane such that the transducer is operative as a micro-heat engine having a thermodynamic cycle (see figs. 7 and 8), wherein thermal energy, flowing from the high-temperature heat source to the low-temperature heat sink through the micro-heat engine during the thermodynamic cycle, is converted into electrical energy.

Wherein the low-temperature heat sink (see fig. 1 at bottom) has at least one thermal switch positioned to thermally couple the low-temperature heat sink and the first membrane (see Heat Rejection part of cycle in fig. 2) at least once during the thermodynamic cycle of the micro-heat engine and the high-temperature heat source has at least one thermal switch positioned to thermally couple the high-temperature heat source and the second membrane (see Heat Addition part of cycle in fig. 2) at least once during the thermodynamic cycle of the micro-heat engine.

Further comprising a low-temperature heat source (fig. 1 at bottom) disposed adjacent the second membrane and a high-temperature heat sink (fig. 1 at top) disposed adjacent the first membrane such that the transducer is operative as a micro-heat pump having a thermodynamic cycle (see figs. 7 and 8), wherein electrical energy is consumed to transfer heat from the low-temperature heat source to the high temperature heat sink.

Wherein the low-temperature heat source has at least one thermal switch positioned to thermally couple the low-temperature heat source and the second membrane at least once during the thermodynamic cycle of the micro-heat pump (see coupling in the Heat Rejection part of the cycle where the heat out part of the cycle is shown), and the high-temperature heat sink has at least one thermal switch positioned to thermally couple the high-temperature heat sink and the first membrane at least once during the thermodynamic cycle of the micro-heat pump (see the 'heat in' in the Heat Addition part of the cycle in fig. 2).

Wherein the working fluid is a saturated mixture of vapor and liquid. See p. 262, col. 1, the first paragraph under the heading "MICRO HEAT ENGINE DESIGN".

Wherein the first membrane comprises a layer of silicon, and the second membrane comprises a layer of silicon for supporting the first and second electrodes and the piezoelectric member. See p. 263, lines 10-15.

Xu et al. show (again figs. 1-3) a micro-transducer comprising: a first layer; a second layer having piezoelectric properties and joined to the first layer so as to form a fluid-tight cavity therebetween; and a working fluid contained within the cavity; wherein thermal energy flowing into the micro-transducer causes the working fluid to expand, thereby distending the second layer for generating an electrical charge.

Wherein the first layer comprises a first substrate forming a first membrane, and the second layer comprises a second substrate forming a second membrane, the micro-transducer further comprising an intermediate layer between the first and second layers and defining a recess, the first membrane, the second membrane and the recess together defining the fluid tight cavity.

Wherein the working fluid is at least a vapor phase. Again, see p. 262, col. 1, the first paragraph under the heading "MICRO HEAT ENGINE DESIGN".

Further comprising a high-temperature heat source positioned to transfer heat energy into the micro-transducer. See Heat Addition part of cycle in fig. 2.

Wherein the high-temperature heat source is positioned to thermally conduct heat energy into the micro-transducer.

Further comprising a low-temperature heat sink (bottom of fig. 1) positioned to receive heat energy from the micro-transducer.

Wherein the low-temperature heat sink is positioned to receive heat energy from the micro-transducer through conduction. For example see Heat Rejection part of cycle in fig. 2 where heat is conducted from the cavity.

Wherein the first layer is more rigid than the second layer so that the second layer distends outwardly and the first layer retains a substantially constant profile whenever heat energy flows into the micro-transducer to expand the working fluid. See fig. 2 where bottom membrane is still.

Xu et al. note at p. 262, col. 2, that their device may consist of "many unit cell engines combined together, thus they note a structure having a plurality of micro-transducers, the structure comprising: a first major layer; a second major layer juxtaposed to the first layer; a plurality of fluid-tight cavities cooperatively formed between the first and second major layers; a working fluid contained in the cavities; a plurality of first electrodes carried by the first major layer at each of said cavities; a plurality of piezoelectric members carried by the first electrodes at each of said cavities; and a plurality of second electrodes carried by the piezoelectric members at each of said cavities.

Wherein each of the first electrodes (see fig. 3) comprises a unitary first metallic layer (gold) overlaying the first surface, the plurality of piezoelectric members comprising a unitary piezoelectric layer (PZT) overlaying the first metallic layer (gold),

and the plurality of second electrodes comprising a unitary second metallic layer (platinum) overlaying the piezoelectric layer.

Further comprising an intermediate layer disposed between the first and second major layers, the intermediate layer defining a plurality of recesses that define respective cavities between the first and second major layers. The intermediate layer forms the walls of the recesses. See fig. 1 for example where the lateral walls of the cavity are formed by this layer which is also noted as being made of Silicon.

Wherein the intermediate layer comprises a photo-resist material. As noted, it is silicon.

Wherein the working fluid is a saturated mixture of vapor and liquid. Again see p.262, ll. 28-30.

As noted above, Xu et al. show (figs. 1-3) a micro-transducer, comprising: a first membrane; a second membrane comprising a first electrode, a second electrode, and a piezoelectric member disposed therebetween; a fluid-tight cavity cooperatively formed between the first and second membranes; a working fluid disposed in the cavity; and a low-temperature heat sink disposed adjacent the first membrane and a high-temperature heat source disposed adjacent the second membrane such that the transducer is operative as a micro-heat engine having a thermodynamic cycle, wherein thermal energy, flowing from the high-temperature heat source to the low-temperature heat sink through the micro-heat engine during the thermodynamic cycle, is converted into electrical energy.

As noted above, the low-temperature heat sink has at least one thermal switch positioned to thermally couple the low-temperature heat sink and the first membrane at least once during the thermodynamic cycle of the micro-heat engine; and the high-temperature heat source has at least one thermal switch positioned to thermally couple the high-temperature heat source and the second membrane at least once during the thermodynamic cycle of the micro-heat engine.

As noted the working fluid comprises a saturated vapor and liquid.

As noted, the first membrane comprises a layer of silicon; and the second membrane comprises a layer of silicon for supporting the first and second electrodes and the piezoelectric member.

The cavity is configured such that the liquid adheres to inside surfaces of the cavity due to surface tension of the liquid, thereby resulting in separation of the liquid from the vapor. See p. 262, the last paragraph in column two until the end of the paragraph.

The working fluid occupies the cavity.

As noted, the first membrane is more rigid than the second membrane such that the second membrane deflects and the first membrane retains a substantially constant profile during the thermodynamic cycle.

As noted above, Xu et al. show a micro-transducer comprising a first membrane; a second membrane comprising a first electrode, a second electrode, and a piezoelectric member disposed therebetween; a fluid-tight cavity cooperatively formed between the first and second membranes; a working fluid occupying substantially the entire cavity; and a low-temperature heat source disposed adjacent the second membrane and a

high-temperature heat sink disposed adjacent the first membrane such that the transducer is operative as a micro-heat pump having a thermodynamic cycle, wherein electrical energy is consumed to transfer heat from the low-temperature heat source to the high-temperature heat sink.

As noted above, the low-temperature heat source has at least one thermal switch positioned to thermally couple the low-temperature heat source and the second membrane at least once during the thermodynamic cycle of the micro-heat pump; and the high-temperature heat sink has at least one thermal switch positioned to thermally couple the high-temperature heat sink and the first membrane at least once during the thermodynamic cycle of the micro-heat pump.

As noted above, the working fluid comprises a saturated vapor and a liquid.

As noted above, the first membrane comprises a layer of silicon, and the second membrane comprises a layer of silicon for supporting the first and second electrodes and the piezoelectric member.

As noted above, the cavity is configured such that the liquid adheres to inside surfaces of the cavity due to surface tension of the liquid, thereby resulting in separation of the liquid from the vapor.

As noted above, the first membrane is more rigid than the second membrane such that the second membrane deforms and the first membrane retains a substantially constant profile during the thermodynamic cycle.

As noted above, a body defining a fluid-tight cavity, a compressible and expansible working fluid contained within and occupying the cavity, the body having a piezoelectric

unit situated adjacent the cavity, and the piezoelectric unit being operable as an actuator to compress the working fluid whenever an electric field is applied to the piezoelectric unit and operable as a generator to generate an electric charge whenever the working fluid expands; a heat source; and a heat sink, the heat source and heat sink being positioned relative to the body such that thermal energy flowing from the heat source to the heat sink flows through the working fluid. See the explanation of compression and expansion in col. 1 of p. 263 in the first two paragraphs.

As noted above, the heat source is a high-temperature heat source; the heat sink is a low-temperature heat sink; and the transducer is operable as a micro-heat engine according to a thermodynamic cycle in which thermal energy, flowing from the heat source to the heat sink through the working fluid, is converted into electrical energy.

As noted above the heat source is a low-temperature heat source (note that heat is conducted into and then out of the working fluid); the heat sink is a high-temperature heat sink (at heat rejection part of the cycle in fig. 2); and the micro-transducer is operative as a micro-heat pump that consumes electrical energy while transferring heat from the low-temperature heat source to the high-temperature heat sink.

As noted, the working fluid comprises a vapor and a liquid.

As noted, the cavity is configured such that the liquid adheres to inside surfaces of the cavity due to surface tension of the liquid, thereby resulting in separation of the liquid from the vapor.

The body comprises first and second opposed major layers; the cavity is formed between the first and second layers; and the cavity has a thickness defined between the first and second layers of about 50 microns or less. See fig. 3.

As noted above, Xu et al. show (figs. 1-3) an apparatus for converting energy in one form to energy in another form, the apparatus comprising: a first major layer; and a second major layer juxtaposed to the first major layer, the first and second major layers forming a plurality of micro-transducers, each micro-transducer comprising a respective fluid-tight cavity formed between the first and second major layers, a compressible working fluid disposed in the cavity, and a respective piezoelectric unit formed on one of the first and second major layers.

As noted, Xu et al. show (figs. 1-3) micro-transducer, comprising: a body defining a fluid-tight cavity; and a compressible and expansible working fluid contained within the cavity, the body having a piezoelectric unit situated adjacent the cavity, and the piezoelectric unit being operable as an actuator to compress the working fluid whenever an electric field is applied to the piezoelectric unit and operable as a generator to generate an electric charge whenever the working fluid expands.

As noted, the working fluid occupies the cavity.

As noted, the body comprises a first membrane and a second membrane; the cavity is formed between the first and second membranes; and the piezoelectric unit is disposed on the first membrane.

As noted, the first membrane is more flexible than the second membrane.

Allowable Subject Matter

Claim 18 is objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims.

The following is a statement of reasons for the indication of allowable subject matter: The prior art does not show or fairly suggest a plurality of micro-transducers with opposing layers forming fluid tight cavities wherein the opposing layers have a plurality of recessed portions in register.

Claims 95-103 are allowed.

The following is an examiner's statement of reasons for allowance: the prior art does not show nor fairly suggest a plurality of fluid-tight cavities which are super-posed on one another and which cavities each have opposing layers forming them, wherein the layers include a piezoelectric components which are employed in energy conversion.

Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

Direct inquiry concerning this action to Examiner Dougherty at (703) 308-1628.

and
tmd

September 5, 2003

